

# POMERON/ODDERON INTERFERENCE IN DIFFRACTIVE MESON PAIRS PRODUCTION

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We study Pomeron-Odderon interference effects giving rise to charge and single-spin asymmetries in diffractive electroproduction of a  $\pi^+ \pi^-$  pair. The final state interactions and the role of  $f_0$  meson are discussed.

Hadronic reactions at low momentum transfer and high energies (for charge-even exchange) are described in QCD in terms of QCD-Pomeron described by the BFKL equation [1]. The charge-odd exchange is less well understood although the corresponding BKP equations [2] have attracted much attention recently [3, 4, 5, 6], thus reviving the relevance of phenomenological studies of the Odderon exchange pointed out years ago in Ref. [7]. Unfortunately, recent experimental studies at HERA of exclusive  $\pi^0$  photoproduction [8] indicate a very small cross section for this process which stays in contradiction with theoretical predictions based on the stochastic vacuum model [9].

The general feature of all meson production processes is that scattering amplitude describing Odderon exchange enters quadratically in the cross section. This observation lead to the suggestion in Ref. [10], that the study of observables where Odderon effects are present at the amplitude level is mandatory to get a convenient sensitivity to a rather small normalization of this contribution. This may be achieved by means of charge asymmetries, for instance

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in open charm production [10]. Another example [11] is the charge asymmetry in soft photoproduction of two pions. Bearing in mind perturbative QCD (pQCD) description, we calculated the "hard" analogs of these asymmetries [12], and supplemented them by the single spin asymmetries, which may be studied at HERA with polarized lepton beam [13]. We consider the process  $e^-(p_e)N(p_N) \rightarrow e^-(p'_e)\pi^+(p_+)\pi^-(p_-)N'(p'_N)$ . The application of pQCD for the calculation of a part of this process is justified by the presence of a hard scale: the squared mass  $-Q^2 = -(p_e - p'_e)^2$  of the virtual photon,  $Q^2$  being of the order of a few  $\text{GeV}^2$ . The amplitude of this process includes the convolution of a perturbatively calculable hard subprocess with two non-perturbative inputs, the 2-pion generalized distribution amplitude (GDA) and the Pomeron-Odderon (P/O) proton impact factors. Since the  $\pi^+\pi^-$  system is not a charge parity eigenstate, the GDA includes two charge parity components and allows for a study of the corresponding interference term. The relevant GDA is just given by the light cone wave function of the two pion system [14]. The GDAs may be accessed in  $\gamma\text{gamma}^*$  exclusive production of two mesons[15]

## 1 Observable asymmetries

We define the forward-backward or charge asymmetry  $A(Q^2, t, m_{2\pi}^2, y, \alpha)$  by

$$\frac{\sum_{\lambda=+,-} \int \cos \theta d\sigma(s, Q^2, t, m_{2\pi}^2, y, \alpha, \theta, \lambda)}{\sum_{\lambda=+,-} \int d\sigma(s, Q^2, t, m_{2\pi}^2, y, \alpha, \theta, \lambda)} \quad (1)$$

as a weighted integral over polar angle  $\theta$  of the relative momentum of two pions. Although this asymmetry depends on full set of the kinematical variables, different dependencies, due to factorization, come from different sources. The most clean one are the dependencies on  $Q^2$ , coming from the hard subprocess, and on dipion mass  $m_{2\pi} = \sqrt{(p_+ + p_-)^2}$ , coming from the GDA. The specific form of  $m_{2\pi}$  dependence is explained by the fact, that the phase of the GDA[14] should add to the phase shift between Pomeron and Odderon.

The latter objects, together with the coefficient functions, define the dependence of asymmetry on  $t = (p_N - p'_N)^2$ . The single spin asymmetry [13]  $A_S(Q^2, t, m_{2\pi}^2, y, \alpha)$  contains extra factor  $\lambda$  in the numerator of (1) and requires to fix the lepton beam polarization  $\lambda$ . Contrary to charge asymmetry, this effect

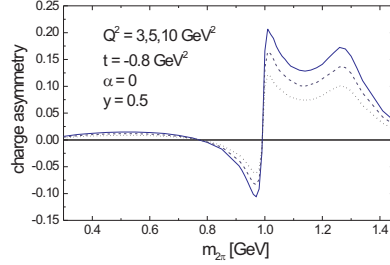


Figure 1: Dependence of charge asymmetry on  $m_{2\pi}$  and  $Q^2$

is proportional to the imaginary, rather than to the real part of the interference term. As the Pomeron amplitude is imaginary and the Odderon one is real the relative phase between them is the maximal one for the emergence of single spin asymmetries [16].

## 2 Charge Asymmetry at lower energies and $f_0$ meson contribution

The interference effects in electroproduction at lower energies leading to the charge asymmetries were already studied both theoretically [17] and experimentally [18]. The QCD factorization implies, that in this situation the P/O impactfactors should be substituted by various Generalized Parton Distributions (GPD), while GDA's are the same as in our case. This would result in the same  $m_{2\pi}$ -dependence of charge asymmetry, provided the phases of hard amplitudes are the same, while their difference leads to the calculable difference of  $m_{2\pi}$ -dependencies. The interesting feature of experimental data is the absence of  $f_0$ -meson contribution, and we would like to comment on this issue.

Let us first recall that the status of the  $f_0$  is very unclear, and different models are proposed for the  $f_0$  structure, where the  $K\bar{K}$  molecule plays a special role [19]. As the  $f_0$  is definitely related to the  $K\bar{K}$  threshold, a coupled channel ( $K\bar{K}$  and  $\pi\bar{\pi}$ ) analysis is obviously needed for the phase shifts analysis above this threshold. If  $q\bar{q}$  component of  $f_0$  is indeed small, it is quite probable, that the  $q\bar{q}$  GDA does not manifest any significant traces of  $f_0$  peak. Taking seriously the absence of  $f_0$  signal suggested by this reasoning and supported by HERMES data leads to different predictions for our P/O interference effects, namely the disappearance of any sizable effect around 950-1000 MeV. The signal to search for would then be near the  $f_2$  mass. Moreover, such a connection opens a possibility to study the meson structure in the hard processes, focusing on the observables, sensitive to the GDA phases, like the asymmetries we are considering.

### 3 Conclusions

We found that a sizable charge asymmetry may be a useful tool to look for QCD Odderon contribution at HERA. The spin asymmetry is smaller, but it can be important at larger  $t$  and smaller  $Q^2$ . Note finally, that the numerical value of our predictions depend on the adopted model for proton impact factors, so the observation of the predicted effects with the different magnitude and/or  $t$ -dependence might be considered as their indirect experimental determination. As a byproduct, the QCD structure of  $f_0$  meson may be investigated.

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